Hydro-climatic Effects of Present and Future Land Cover / Land Use Changes in the Upper Mesopotamia

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Motivation

Euphrates & Tigris Basin

Bozkurt and Sen, J. of Hydro., 2013

- Snow-fed river basin
- Irrigated cultivation
- Southeastern Anatolia Project
- Streamflow timings are shifting to earlier days in the year
Southeastern Anatolia Project (SAP)

1.8 million ha

- Energy Production
- Agricultural Irrigation
- Water release to downstream countries

Precipitation
Climate change
Land cover
Land use change

Potential for conflict
Objectives

- To reveal the **effect of LCLU changes** as a result of irrigation projects within the scope of GAP in the ETB on the climate and water resources of the region.

- To calculate the **water loss** via evapotranspiration from the region due to extension of irrigated cultivation.

Method

- **RegCM4** (revision 4283)
  - BATS – land surface model (with subgrid option)

- Simulations (with default + current and future landuse maps)

<table>
<thead>
<tr>
<th>Simulation name</th>
<th>OD48 (48 km)</th>
<th>TR12 (12 km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid number (y,x), Vertical Resolution</td>
<td>75x95, 18 level</td>
<td>100x160, 23 level</td>
</tr>
<tr>
<td>Center (latitude, longitude)</td>
<td>40, 32</td>
<td>38.7, 37</td>
</tr>
<tr>
<td>Initial and Boundary Conditions (atmosphere, sst)</td>
<td>NNRP, OI_WK</td>
<td>NNRP, OI_WK</td>
</tr>
<tr>
<td>Boundary Condition Parameters (nspgx, nspgd)</td>
<td>12,12</td>
<td>18,18</td>
</tr>
<tr>
<td>Boundary Layer Model</td>
<td>Holtslag PBL</td>
<td>Holtslag PBL</td>
</tr>
<tr>
<td>Cumulus Convection Scheme</td>
<td>Grell</td>
<td>Grell</td>
</tr>
<tr>
<td>Cumulus Closure Scheme</td>
<td>Fritsch &amp; Chappell</td>
<td>Fritsch &amp; Chappell</td>
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<tr>
<td>Moisture Scheme</td>
<td>SUBEX</td>
<td>SUBEX</td>
</tr>
<tr>
<td>Ocean Flux Scheme</td>
<td>Zeng</td>
<td>Zeng</td>
</tr>
<tr>
<td>Radiation Model</td>
<td>CCSM</td>
<td>CCSM</td>
</tr>
</tbody>
</table>
Study Domain

- Eastern Mediterranean and Black Sea (OD - 48 km)
- Turkey (TR - 12 km)
Model Setup

- **Forcing data sets**
  - Reanalysis (**NNRP** – NCEP/NCAR Reanalysis)
  - GCM (Global Circulation Model) (**EC-EARTH**)

- **Model Validation (Observation)**
  - **CRU** (Climate Research Unit)
  - High Resolution Gridded Data
  - 0.5° x 0.5°

- **Temperature, precipitation, evapotranspiration**
  - 1991 – 2010 (**20 years**) -> NNRP
  - 1986 – 2009 (**24 years**) -> EC-EARTH
Landuse Maps

1993 period
• Pre-SAP
• GLCC (USGS)

2000 period
• SAP (25%)  
• CORINE (EEA)

Future
• SAP (%100)  
• DSI (Turkish State Hydraulic Work)
Model Performance

1991-2008 / Mean Annual Temperature

MODEL

OD48d_nnrp_rf

Celsius (°C)

50°N
45°N
40°N
35°N
30°N
25°N
20°E 30°E 40°E 50°E

CRU

OBS

DIFF

OD48d_nnrp_rf-CRU

Celsius (°C)

DIFF

OD48d_gcm_rf

Celsius (°C)

50°N
45°N
40°N
35°N
30°N
25°N
20°E 30°E 40°E 50°E

CRU

GCM

DIFF

OD48d_gcm_rf-CRU

Celsius (°C)

NNRP

GCM
Model Performance

1991-2008 / Mean Annual Total Precipitation
Temperature

Precipitation

Evapotranspiration

Pre-SAP

SAP (25%)

SAP (100%)
## Water Budget

<table>
<thead>
<tr>
<th></th>
<th>Pre-SAP</th>
<th>SAP (25%)</th>
<th>SAP (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Past</td>
<td>Current</td>
<td>Future</td>
</tr>
<tr>
<td><strong>Upper E&amp;T</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>935.553</td>
<td>946.665 (1% ↑)</td>
<td>963.516 (3% ↑)</td>
</tr>
<tr>
<td>ET</td>
<td>534.584</td>
<td>540.868 (1% ↑)</td>
<td>550.177 (3% ↑)</td>
</tr>
<tr>
<td>P-ET</td>
<td>400.969</td>
<td>405.797</td>
<td>413.339</td>
</tr>
<tr>
<td><strong>SAP region</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>510.336</td>
<td>527.121 (3% ↑)</td>
<td>544.748 (7% ↑)</td>
</tr>
<tr>
<td>ET</td>
<td>420.746</td>
<td>637.374 (51% ↑)</td>
<td>901.293 (114% ↑)</td>
</tr>
<tr>
<td>P-ET</td>
<td>89.590</td>
<td>-110.253</td>
<td>-356.545</td>
</tr>
</tbody>
</table>

P : Precipitation  
ET : Evapotranspiration

*unit (mm/year)
Summary

In the SAP region annually, due to the LCLU changes:
- 0.4-0.8 °C decrease in temperature
- 3-7% increase in precipitation
- 51-114% increase in evapotranspiration

Increases in precipitation and evapotranspiration amounts in the upper Mesopotamia have been calculated mostly over the SAP region.

The study is currently being extended to simulate integrated effects of future climate changes (RCP 4.5 and RCP 8.5 scenarios by using EC-EARTH) with anthropogenic climate changes (land cover land use changes) for the assessment of possible changes in the regional water budget.
Thank you*

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